CHAPTER 6: PREVENTION PROGRAM (PROGRAM 2)

6.1 ABOUT THE PROGRAM 2 PREVENTION PROGRAM

EPA developed the Program 2 prevention program by identifying the basic elements that are the foundation of sound prevention practices — safety information, hazard review, operating procedures, training, maintenance, compliance audits, and accident investigation. By meeting other Federal regulations, state laws, industry codes and standards, and good engineering practices, you probably have already met most of the Program 2 prevention elements requirements.

As important as each of the elements is, you will not gain the full benefit from them unless you integrate them into a risk management system that you implement on an on-going basis. For example, the hazard review must be built on the safety information; the results of the hazard review should be used to revise and update operating and maintenance procedures. Workers must be trained in these procedures and must use them every day.

You will have substantially less documentation and recordkeeping responsibilities for a Program 2 process than you will for a Program 3 process. There are seven elements in the Program 2 prevention program, which is set forth Subpart C of part 68. Exhibit 6-1 sets out each of the seven elements and corresponding section numbers.

You must integrate these seven elements into a risk management program that you and your staff implement on a daily basis. Understanding and managing risks must be part of the way you operate. Doing so will provide benefits beyond accident prevention. Preventive maintenance and routine inspections will reduce the number of equipment failures and down time; well-trained workers, aware of optimum operating parameters, will allow you to gain the most efficient use of your processes and raw materials.

6.2 SAFETY INFORMATION (§ 68.48)

The purpose of this requirement is to ensure that you understand the safety-related aspects of the equipment and processes you have, know what limits they place on your operations, and adopt accepted standards and codes where they apply. Having up-to-date safety information about your process is the foundation of an effective prevention program. Many elements (especially the hazard review) depend on the accuracy and thoroughness of the information this element requires you to provide.

EXHIBIT 6-1
SUMMARY OF PROGRAM 2 PREVENTION PROGRAM

Number	Section Title
§ 68.48	Safety Information
§ 68.50	Hazard Review
§ 68.52	Operating Procedures
§ 68.54	Training
§ 68.56	Maintenance
§ 68.58	Compliance Audits
§ 68.60	Incident Investigation

WHAT DO I NEED TO DO?

You must compile and maintain safety information related to the regulated substances and process equipment for each Program 2 process. You probably have much of this information already as a result of complying with OSHA standards or other rules. EPA has limited the information to what is likely to apply to the processes covered under the Program 2 program. Exhibit 6-2 gives a brief summary of the safety information requirements for Program 2.

HOW DO I START?

MSDSs. If you are subject to this rule, you may also be subject to the requirements to maintain Material Safety Data Sheets under the OSHA Hazard Communication Standard (HCS) (29 CFR 1910.1200). POTWs in states with delegated OSHA programs and all private WWTPs are subject to OSHA's HCS.

If you do not have an MSDS for a regulated substance, you should contact your supplier or the manufacturer for a copy. Because methane (CH_4) is generated in your plant, you will have to find an MSDS elsewhere. A local utility supplying natural gas may have one. You may, however, have to add the potential for inclusion of carbon dioxide, hydrogen sulfide, and water in the methane stream. If these are present, then the corrosivity information about that stream will be needed. You may wish to ask assistance from a process engineer.

Because the rule states that you must have an MSDS that meets OSHA requirements, you may want to review the MSDS to ensure that it is, in fact, complete. Besides providing the chemical name, the MSDS for a regulated substance (or a mixture containing the regulated substance) must describe the substance's physical and

chemical characteristics (e.g., flash point, vapor pressure), physical hazards (e.g., flammability, reactivity), health hazards, routes of entry, exposure limits (e.g., the OSHA permissible exposure level), precautions for safe handling, generally applicable control measures, and emergency and first aid procedures. (See 29 CFR 1910.1200(g) for the complete set of requirements for an MSDS.)

EXHIBIT 6-2
SAFETY INFORMATION REQUIREMENTS

You must compile and maintain this safety information:	You must ensure:	You must update the safety information if:
U Material Safety Data Sheets **U** Maximum intended inventory **U** Safe upper and lower parameters **U** Equipment specifications **U** Codes & standards used to design, build, and operate the process	**U** That the process is designed in compliance with recognized codes and standards	**U** There is a *major change* at your business that makes the safety information inaccurate

Maximum Inventory. You must document the maximum intended inventory of any vessel in which you store or process a regulated substance above its threshold quantity. The U1A certificates on all vessels constructed under the ASME Boiler and Pressure Vessel Code are kept on file by the National Board (see chapter 1). The nominal nameplate capacity can also be found on the permanently attached nameplate for your storage tank. The nameplate will also have the National Board Number for your vessel, which is the key to retrieving your U1A form from the Board. These nameplates may be located on one of the hemispherical heads, the manway, or the manway cover. The nominal capacity will usually be the water capacity, and you may want to convert it to pounds.

If you use transportation containers (railcars or tank trucks) as storage vessels, you can obtain the capacity from the required DOT nameplate, identification plate, or specification plate or from the owner of the containers. Smaller shipping containers are also marked. If you are not sure of the capacity of the vessel, you can obtain this information from the manufacturer of the vessel or tank.

The Chlorine Institute recommends that chlorine tanks not be filled beyond 95 percent at a maximum temperature of 122EF. OSHA regulations limit liquid volumes of unrefrigerated anhydrous ammonia to the following:

Type of Container	Percent by Weight	Percent by Volume
Aboveground-Uninsulated	56%	82%
Aboveground-Uninsulated*		87.5%
Aboveground-Insulated	57%	83.5%
Underground-Uninsulated	58%	85%

*Aboveground uninsulated containers may be charged to 87.5 percent by volume if the temperature of the anhydrous ammonia being charged is determined to be not lower than 30EF or if the charging container is stopped at the first indication of frost or ice formation on its outside surface and is not resumed until such frost or ice has disappeared. (29 CFR 1910.111(b)(11))

Aqueous ammonia may be held in various concentrations; your supplier can provide the density and weight. You can use this information, with your tank capacity, to estimate the quantity of ammonia being stored.

The Compressed Gas Association provides the following recommendations for filling sulfur dioxide tanks at varying temperatures (CGA pamphlet G-3):

Temperature of Liquid SO_2 in Tank EF	Maximum Safe Volume Liquid SO_2 in % of Full Volume at 125% Filling Density
30	86
40	87
50	88
60	89
70	90
80	91
90	92
100	93

Storage and Process Limits. You must document the safe upper and lower temperatures and pressures, process flows (if applicable), and compositions (if applicable) for your process.

Every substance has limits on the temperature and pressures at which it can be stored or used; these limits are determined by both the properties of the substance and the vessels it which it is kept. If you do not know these limits, you should contact your

vendor, the substance manufacturer, or your trade association. They will be able to provide the data you need. Some of this information (e.g., maximum pressure) may be marked on the nameplate or container. It is important that you know these limits so you can take action to avoid situations where these limits may be exceeded. Many people are aware of the dangers of overheating their vessels, but extreme low temperatures also may pose hazards you should know about.

If you are moving substances through pipes or hoses, you need to define safe temperatures and pressures for that movement; again, these limits will be determined by both the substance and the piping. For example, the substance may tolerate high pressures, but the pipes may have structural limits. To operate safely, you must have this information. The pipe manufacturer will be able to provide these data.

The requirement to compile and maintain information on process flows and compositions will apply to you if you transfer substances through piping or hoses and if you mix or react the substance. It is important in these cases that you understand the safe limits for flow and composition. The pipe or hose vendors will be able to provide you with the maximum flow rates that their products are designed to handle. You must also be aware of any hazards that could be created if your processes are contaminated; for example, if your substance or equipment could be contaminated by water, you must know whether that creates different hazards, such as corrosion. Chlorine and SO_2 become very corrosive if mixed with water. In addition, corrosion can occur in digester gas systems if attention is not paid to the corrosive effects of hydrogen sulfide and water that are found in digester gas.

Equipment Specifications. You must document the specifications of any equipment you use to store or move regulated substances in a covered process. Equipment specifications will usually include information on the materials of construction, actual design, and tolerances. The vendor should be able to provide this information; you may have the specifications in your files from the time of purchase. Some of this information (e.g., wall thickness) may be marked on the nameplate or container. You are not expected to develop engineering drawings of your equipment to meet this requirement, but you must be able to document that your equipment is appropriate for the substances and activities for which it is used, and you must know what the limits of the equipment are.

Specifications are particularly important if your vessels or pipes are not specifically designed for your type of operation. Substances may react with certain metals or corrode them if water is introduced. You should be sure that the vessels you purchase or lease are appropriate for your operations. Understanding equipment specifications will help you when you need to buy replacement parts. Any such parts must be appropriate for your existing equipment and your use of that equipment. It is not sufficient to replace parts with something that "fits" unless the new part meets the specifications; substitution of inappropriate parts may create serious hazards.

Codes and Standards. You must document the codes and standards you used to design and build your facility and that you follow to operate. These codes will probably include the electrical and building codes that you must comply with under

state or local laws. Your equipment vendors will be able to provide you with information on the codes they comply with for their products; the information may also be listed on your equipment specifications. Exhibit 6-3 lists some codes that may be relevant to your operation. Note that the National Fire Protection Association (NFPA) codes may have been adopted as state or local codes. NFPA-820 (Standard for Fire Protection in Wastewater Treatment and Collection Facilities) is specific to your industry and provides references to other applicable NFPA codes. The American National Standards Institute (ANSI) is an umbrella standards-setting organization, which imposes a specific process for gaining approval of standards and codes. ANSI codes may include codes and standards also issued by other organizations.

EXHIBIT 6-3
CODES AND STANDARDS

ORGANIZATION	SUBJECT/CODES
American National Standards Institute (ANSI)	Piping, Electrical, Power wiring, Instrumentation, Lighting, Product storage and handling, Insulation and fireproofing, Painting and coating, Ventilation, Noise and Vibration, Fire protection equipment, Safety equipment, Pumps, Compressors, Motors, Refrigeration equipment, Pneumatic conveying; ANSI K61.1 covers storage and handling of anhydrous ammonia
American Society of Mechanical Engineers (ASME)	Power boilers, Pressure vessels, Compressors, Shell and tube exchangers, Vessel components, General design and fabrication codes
American Petroleum Institute (API)	Welded tanks, Rotating equipment, Bulk liquid storage systems
National Fire Protection Association (NFPA)	Wastewater treatment facilities (NFPA-820), Fire pumps, Flammable liquid code (NFPA-30), Plant equipment and layout, Electrical system design, Shutdown systems, Pressure relief equipment, Venting requirements, Gas turbines and engines, Cooling towers, Storage tanks
American Society for Testing Materials (ASTM)	Inspection and testing, Noise and vibration, Materials of construction, Piping materials and systems, Instrumentation
American Concrete Institute	Construction and inspection of concrete tanks, including wastewater treatment plants

HOW DO I DOCUMENT ALL THIS?

EPA does not expect you to develop piles of papers to document your safety information. Your MSDS(s) are usually three or four pages long. You only have to keep them on file, as you already do for OSHA if you are subject to the OSHA

hazard communication standard (29 CFR 1910.1200). Equipment specifications are usually on a few sheets or in a booklet provided by the vendor; you need only keep these on file. You can probably document the other information on a single sheet that simply lists each of the required items and any codes or standards that apply. See Exhibit 6-4 for a sample developed for EPA's guidance for propane storage facilities. Maintain that sheet in a file and update it whenever any item changes or new equipment is added. Although the rule does not require you to create a process flow diagram, you may want to do this as another way of documenting much of this information.

EXHIBIT 6-4
SAMPLE SAFETY INFORMATION SHEET

PROPANE STORAGE	
MSDS Propane	On file (1994)
Maximum Intended Inventory	400,000 pounds
Temperature	Upper: max 110EF Lower: min -15EF
Pressure	Upper: 240 psi @ 110EF Lower: 35 psi @ -15EF
Flow Rate	Loading: 100 GPM (max) Unloading: 265 GPM (max)
Vapor Piping	250 PSIG
Liquid Piping and Compressor Discharge	350 PSIG
Safety Relief Valves	Each relieves 9,250 SCFM/air RV 1 replaced 9/96 RV 2 replaced 6/97 RV 3 replaced 8/98
Excess Flow Valve	3", closes at 225 GPM with 100 PSIG inlet 2", closes at 100 GPM with 100 PSIG inlet 2", closes at 34,500 SCFH with 100 PSIG inlet
Emergency Shutoff Valve	ESV 1 1/4", closes at 26,000 SCFH with 100 PSIG inlet ESV 2", closes at 225 GPM with 100 PSIG inlet
Codes and Standards	Designed under NFPA-58-1985
Piping Design	ASME B31-3
Tank Design	ASME NB# 0012

The equipment specifications and list of standards and codes will probably meet the requirement that you ensure that your process is designed in compliance with recognized and generally good engineering practices. If you have any doubt that you are meeting this requirement, your trade association may be helpful in determining if there are practices or standards that you are not aware of that may be useful in your operation.

After you have documented your safety information, you should double check it to be sure that the files you have reflect the equipment you are currently using. It is important to keep this information up to date. Whenever you replace equipment, be sure that you put the new equipment specifications in the file and consider whether any of your other prevention elements need to be reviewed to reflect the new equipment.

WHERE TO GO FOR MORE INFORMATION

MSDSs. MSDSs are available from a number of websites. The University of Vermont provides access to three university-maintained MSDS collections through its website, http://www.hazard.com. The on-line databases usually have multiple copies of MSDSs for each substance and can help you find an MSDS that is well organized and easy to read. EPA has not verified the accuracy or completeness of MSDSs on any of these sites nor does it endorse any particular version of an MSDS. You should review any MSDS you use to ensure that it meets the requirements of OSHA's hazard communication standard (29 CFR 1910.1200).

Guidance and Reports. Although the reports below target the chemical industry, you may find useful information in them:

- Guidelines for Process Safety Documentation, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1995.
- Loss Prevention in the Process Industries, Volumes I, II, and III, Frank P. Lees, Butterworths: London 1996.

The Chlorine Institute publishes a number of documents on chlorine handling, including:

- Chlorine Vaporizing Systems, Pamphlet # 9.
- Cylinder and Ton Container Procedures for Chlorine Packaging, Pamphlet # 17.
- Water and Wastewater Operators Chlorine Handbook, Pamphlet # 155.

The Compressed Gas Association publishes:

- *Sulfur Dioxide* on properties, storage, handling, and use of sulfur dioxide (Order # G-3).
- ANSI K61.1 on the storage and handling of anhydrous ammonia (Order # G 2.1).

- *Anhydrous Ammonia* on properties, storage, handling, and use of anhydrous ammonia (Order # G-2).

The Water Environment Federations publishes the following:

- *Operation and Maintenance of Municipal Wastewater Treatment Plants* (MOP-11), Water Environment Federation.

6.3 HAZARD REVIEW (§ 68.50)

For a Program 2 process, you must conduct a hazard review. EPA has streamlined the process hazard analysis (PHA) requirement of OSHA's PSM standard to create a requirement that will detect process hazards for processes in Program 2. The hazard review will help you determine whether you are meeting applicable codes and standards, identify and evaluate the types of potential failures, and focus your emergency response planning efforts.

WHAT DO I NEED TO DO?

The hazard review is key to understanding how to operate safely on a continuous basis. You must identify and review specific hazards and safeguards for your Program 2 processes. EPA lists the types of hazards and safeguards in the rule. Exhibit 6-5 summarizes things you must do for a hazard review.

EXHIBIT 6-5
HAZARD REVIEW REQUIREMENTS

Conduct a review & identify...	Use a guide for conducting the review.	Document results & resolve problems.	Update your hazard review.
U The hazards associated with the Program 2 process & regulated substances. U Opportunities for equipment malfunction or human error that could cause a release. U Safeguards that will control the hazards or prevent the malfunction or error. U Steps to detect or monitor releases.	U You may use a checklist. U For a process designed to industry standards like NFPA-58 or Federal /state design rules, check the equipment to make sure that it's fabricated, installed, and operated properly.	U Your hazard review must be documented and you must show that you have addressed problems.	U You must update your review at least once every five years or whenever there is a major change in the process. U You must resolve problems identified in the new review *before* you startup the changed process.

WHAT METHOD SHOULD I USE?

This guidance provides information on three hazard evaluation methods:

- Checklist
- What-If/Checklist
- Hazard and Operability (HAZOP) Review

Checklist. When your facility has been designed and built to comply with a federal or state standard or an industry-specific design code, it may be possible to develop a checklist that, in and of itself, will be sufficient to conduct the hazard review.

Some sample checklists for chemicals at wastewater treatment facilities are provided in the appendix to this chapter as follows:

Exhibit 6A-1	General Conditions, Operation and Maintenance
Exhibit 6A-2	Human Factors
Exhibit 6A-3	Checklists for Chlorine and Sulfur Dioxide
Exhibit 6A-4	Checklist for Anhydrous Ammonia Systems
Exhibit 6A-5	Checklist for Aqueous Ammonia Systems

Finally, you may also develop your own checklist or supplement those given in this guidance to make sure they are appropriate for your site. The review must identify the following:

- The hazards of the substance (e.g., toxicity, flammability, corrosivity) and process (e.g., overpressurization, overfilling, inadvertent mixing);
- Possible equipment failures or human errors that could lead to a release;
- Safeguards used to prevent failures or errors; and
- Steps needed to detect or monitor releases.

You should maintain a copy of the checklist you used. The easiest way to document findings is to enter them into the checklist after each item, in the comment section. This approach will give you a simple, concise way of keeping track of findings and recommendations. You may also want to create a separate document of recommendations that require implementation or other resolution. EPA does not require that you implement every recommendation. It is up to you to decide which recommendations are technically feasible and warrant implementation. You may decide that other steps are as effective as the recommended actions or that the risk is too low to merit the expense. You must, however, document your decision on each recommendation.

What-If/Checklist Analysis. The success of the checklist approach depends on the experience of those who fill out the checklist. To ensure that the identification of hazards is as complete as possible, it is often useful to supplement the checklist with a What-If analysis. As the name implies, the What-If/Checklist Analysis technique is a combination of two methods: What-If Analysis and Checklist Analysis. The analysis is usually performed by a team of personnel experienced with the subject

process. The team uses the What-If Analysis technique to brainstorm the various types of accidents that can occur within the process. The team then uses one or more checklists to help fill in any gaps they may have missed.

The examples of What-If questions in Exhibit 6A-6 are derived from a variety of sources, including:

- "Guidelines for Hazard Evaluation Procedures - Second Edition with Worked Examples," published by the Center for Chemical Process Safety (CCPS), New York, 1992
- Information collected from various wastewater treatment facilities during the development of this guidance
- Information from industry associations such as the Chlorine Institute and the International Institute of Ammonia Refrigeration (IIAR), and
- The American Water Works Association (AWWA).

Hazard and Operability Analysis. The Hazard and Operability (HAZOP) Analysis technique is based on the principle that several experts with different backgrounds can interact in a creative, systematic fashion and identify more problems when working together than when working separately and combining their results. Although the HAZOP Analysis technique was originally developed for evaluation of a new design or technology, it is applicable to almost all phases of a process' lifetime.

The essence of the HAZOP Analysis approach is to review process drawings and/or procedures in a series of meetings, during which a multi disciplinary team uses a prescribed protocol to methodically evaluate the significance of deviations from the normal design intention.

The primary advantage of the brainstorming associated with HAZOP Analysis is that it stimulates creativity and generates new ideas. This creativity results from the interaction of a team with diverse backgrounds. Consequently, the success of the study requires that all participants freely express their views, but participants should refrain from criticizing each other to avoid stifling the creative process. This creative approach, combined with the use of a systematic protocol for examining hazardous situations, helps improve the thoroughness of the study.

The HAZOP study focuses on specific points of the process or operation called "study nodes," process sections, or operating steps. One at a time, the HAZOP team examines each section or step for potentially hazardous process deviations that are derived from a set of established guide words. One purpose of the guide words is to ensure that all relevant deviations of process parameters are evaluated. Sometimes teams consider a fairly large number of deviations (i.e., up to 10 to 20) for each section or step and identify their potential causes and consequences. Normally, all of the deviations for a given section or step are analyzed by the team before it proceeds further. Exhibit 6A-8 shows how deviations are determined by combining guide words and process parameters.

CAUTION

Whichever approach you use, you should consider reasonably anticipated external events as well as internal failures. If you are in an area subject to earthquakes, hurricanes, or floods, you should examine whether your process would survive these natural events without releasing the substance. In your hazard review, you should consider the potential impacts of lightning strikes and power failures. If your process could be hit by vehicles, you should examine the consequences of that. If you have anything near the process that could burn, ask yourself what would happen if the fire affected the process. For example, if you have a propane tank and an ammonia tank at your facility and they are close to each other, when you look at the ammonia tank you should consider what a fire in the propane tank would do to the ammonia. These considerations may not be part of standard checklists. If you use these checklists, you may have to modify them to address these site-specific concerns. **Never use someone else's checklist blindly. You must be sure that it addresses all of your potential problems.**

In addition, you may want to check with vendors, trade associations, or professional organizations to determine if there are new standards for safety systems or designs, or if there are detection or mitigation systems that may be applicable to your process that you should consider when you evaluate your existing equipment. If your equipment is designed and built to an earlier version of a standard, you should consider whether upgrades are needed.

RESPONDING TO FINDINGS

The person or persons who conduct the review should develop a list of findings and recommendations. You must ensure that problems identified are addressed in a timely manner. EPA does not require that you implement every recommendation. It is up to you to decide which recommendations are necessary and feasible. You may decide that other steps are as effective as the recommended actions or that the risk is too low to merit the expense. You must, however, document your decision on each recommendation. If you are implementing a recommendation, you should document the schedule for implementation. If you are taking other steps to address the problem or decide the problem does not merit action, you should document the basis for your decision.

UPDATES

You must update the review every five years or whenever a major change in a process occurs. For most Program 2 processes, major changes are likely to occur infrequently. If you install a new tank next to an existing one, you would want to consider whether the closeness of the two creates any new hazards. Replacing a tank with an identical tank would not be considered a change. Replacing a tank with a new type of tank should trigger an update. Changing process composition or safe operating limits is considered a major change. Even if changes prove to be minor, you should examine the process carefully before starting. Combining old and new

equipment can sometimes create unexpected hazards. You will operate more safely if you take the time to evaluate the hazards before proceeding.

WHERE TO GO FOR MORE INFORMATION

Although the reports below target the chemical industry, you may find useful information in them:

- *Guidelines for Hazard Evaluation Procedures, 2nd Ed. with Worked examples*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1992.
- *Evaluating Process Safety in the Chemical Industry*, Chemical Manufacturers Association.
- *Loss Prevention in the Process Industries*, Volumes I, II, and III Frank P. Lees, Butterworths: London 1996.
- *Management of Process Hazards* (R.P. 750), American Petroleum Institute.
- *Risk-Based Decision Making (Publication 16288)*, American Petroleum Institute.

Among the information you will find in *Guidelines for Hazard Evaluation Procedures* are descriptions of other PHA techniques, including Failure Modes and Effects Analysis and Fault Tree Analysis. The regulations allow you to make use of these if you wish to do so.

6.4 OPERATING PROCEDURES (§ 68.52)

Written operating procedures describe in detail what tasks a process operator must perform, set safe process operating parameters that must be maintained, and set safety precautions for operations and maintenance activities. These procedures are the guide for telling your employees how to work safely everyday, giving everyone a quick source of information that can prevent or mitigate the effects of an accident, and providing workers and management with a standard against which to assess performance.

WHAT DO I NEED TO DO?

You must prepare written operating procedures that give workers clear instruction for safely conducting activities involving a covered process. You may use standardized procedures developed by industry groups or provided in industry-specific risk management program guidances as the basis for your operating procedures, but be sure to check that these standard procedures are appropriate for your activities. If necessary, you must update your Program 2 operating procedures whenever there is a major change and before you startup the changed process. Exhibit 6-6 briefly summarizes what your operating procedures must address.

EXHIBIT 6-6
OPERATING PROCEDURES REQUIREMENTS

Steps for each operating phase	Other Procedures
U Initial startup	**U** Consequences of deviating
U Normal operations	**U** Steps to avoid, correct deviations
U Temporary operations	**U** Equipment inspections
U Emergency shutdown	
U Emergency operations	
U Normal shutdown	
U Startup following a normal or emergency shutdown or a major change	

Your operating procedures must be:

- **g** Appropriate for your equipment and operations;
- **g** Complete;
- **g** Written in language that is easily understood by your operators; and
- **g** Arranged and organized to be easy for operators to use.

The procedures do not have to be long. If you have simple equipment that requires a few basic steps, that is all you have to cover.

HOW DO I START?

If you already have written procedures, you may not have to do anything more. Review the procedures. You may want to watch operators performing the steps to be sure that the procedures are being used and are appropriate. Talk with the operators to identify any problems they have identified and any improvements they may have made. When you are satisfied that they meet the criteria listed above, you are finished. You may want to check them against any recommended procedures provided by equipment manufacturers, trade associations, or standard setting organizations, but you are not required to do so. You are responsible for ensuring that the procedures explain how to operate your equipment and processes safely.

If you do not have written procedures, you may be able to review your standard procedures with your operators and write them down. You also may want to check with equipment manufacturers, trade associations, or standard setting organizations. They may have recommended practices and procedures that you can adapt. Do not accept anyone else's procedures without checking to be sure that they are adequate and appropriate for your particular equipment and uses and are written in language that your operators will understand. You may also want to review any requirements imposed under state or federal rules. For example, if you are subject to federal rules

for loading and unloading of hazardous materials, those rules may dictate some procedures. Copies of these rules are sufficient for those operations if your operators can understand and use them.

WHAT DO THESE PROCEDURES MEAN?

The rule lists eight procedures. Not all of them may be applicable to you. The following is a brief description to help you decide whether you need to develop procedures for each item. If a particular element does not apply, do not spend any time on it. We do not expect you to create a document that is meaningless to you. You should spend your time on items that will be useful to you.

Initial Startup. This item applies primarily to facilities that process or use substances and covers all the steps you need to take before you start a process for the first time. You should include all the steps needed to check out equipment as well as the steps needed to start the process itself.

Normal Operations. These procedures should cover your basic operations. The procedures would include all the steps operators take to check the process and ensure that equipment is functioning properly and substances are flowing or mixing appropriately. These are your core procedures that you expect your operators to follow on a daily basis to run your processes safely.

At a WWTP, it will be especially important to detail, very specifically, the procedures and safeguards for connecting and disconnecting cylinders, tank trucks, or rail cars containing regulated substances. These procedures should also detail the required precautions, e.g., having an emergency respirator readily available. Also, assuring that emergency equipment is functional and readily available should be part of the instructions. For example, an inspection of the air tank on the self-contained breathing apparatus prior to making or breaking connections should be considered.

Temporary Operations. These operations are short-term; they will usually occur either when your regular process is down or when additional capacity is needed for a limited period. The procedures should cover the steps you need to take to ensure that these operations will function safely. The procedures will generally cover pre-startup checks and determinations (e.g., have you determined what the maximum flow rate will be). The actual operating procedures for running the temporary process must be written before the operation is put into place.

Emergency Shutdowns and Operations. These procedures cover the steps you need to take if you must shutdown your process quickly. For most Program 2 facilities, these procedures will be brief because shutting a process down will be little different in an emergency than in ordinary circumstances; you will simply shut off the flow or stop any unloading or loading.

Normal Shutdown. These procedures should provide all the steps needed to stop a process safely. The procedures should set out the time that should be taken and the checks that must be made before proceeding to the next steps.

Startup following a normal or emergency shutdown or a major change. These procedures may be similar to those for initial startup. Startup procedures following normal shutdown may include fewer equipment checks because you may not need to check equipment on a frequent basis. You should include all the steps your workers should take to ensure that the process can operate safely. Startup after an emergency shutdown will generally require more checks to ensure that valves that were closed are open and that they and other equipment are still functioning properly.

Consequences of Deviations. Your operating procedures should tell the workers what will happen if something starts to go wrong. For example, if the pressure or temperature begins to rise or fall unexpectedly or the flow rate from one feed suddenly drops sharply, the operator must know (1) whether this poses a problem that must be addressed, and (2) what steps to take to correct the problem or otherwise respond to it. Your safety information will have defined the safe operating limits for your substances and processes; the hazard review will have defined the possible consequences and the steps needed to prevent a deviation from causing serious problems. You should include this information in each of the other procedures (startup, normal operations, shutdowns), rather than as separate documents.

If your substance is one that has a distinctive odor, color, or other characteristic that operators will be able to sense, you should include in your procedures information about what to do if they notice leaks. Frequently, people are the most sensitive leak detectors. Take advantage of their abilities to catch leaks before they become serious.

Equipment Inspections. You should include steps for routine inspection of equipment by operators as part of your other procedures. These inspections cover the items that operators should look for on a daily basis to be sure that the equipment is running safely (e.g., vibration checks). These inspections are not the same as those detailed checks that maintenance workers will perform, but rather are the "eyeball," "sound," and "feel" tests that experienced operators do, often without realizing it. Your operators, your vendors, and your trade association can help you define the things that should trigger concern: When is a small leak at a seal normal; when is it a cause of concern? How much vibration is normal? What does a smoothly running motor sound like?

UPDATING PROCEDURES

You must update your procedures whenever you change your process in a way that alters the steps needed to operate safely. If you add new equipment, you will need to expand your procedures or develop a separate set to cover the new items. Whenever you change your safety information you should review your procedures to be sure that they are still appropriate. Anytime you conduct a hazard review, check your operating procedures as you implement changes to address hazards.

WHAT KIND OF DOCUMENTS DO I HAVE TO KEEP?

You must maintain your current set of operating procedures. You are not required to keep old versions; in fact, you should avoid doing so because keeping copies of outdated procedures may cause confusion. You should date all procedures so you will know when they were last updated.

WHERE TO GO FOR MORE INFORMATION

The Chlorine Institute (http://www.cl2.com) publishes information on safe use and handling of chlorine. Its *Water and Wastewater Operators Chlorine Handbook* (Pamphlet # 155) provides general training and procedures.

The Water Environment Federation (601 Wythe Street, Alexandria, VA 22134, (703) 684-2470) provides general procedures as part of its training programs on wastewater treatment operation and maintenance.

Although the reports below target the chemical industry, you may find useful information in them:

- *Guidelines for Process Safety Fundamentals for General Plant Operations*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1995.
- *Guidelines for Safe Process Operations and Maintenance*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1995
- *Guidelines for Writing Effective Operating and Maintenance Procedures*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1996.

6.5 TRAINING (§ 68.54)

Training programs often provide immediate benefits because trained workers have fewer accidents, damage less equipment, and improve operational efficiency. Training gives workers the information they need to understand how to operate safely and why safe operations are necessary. A training program, including refresher training, is the key to ensuring that the rest of your prevention program is effective. You may already have some type of training program if you must conduct training to comply with OSHA's Hazard Communication Standard (29 CFR 1910.1200).

WHAT DO I NEED TO DO?

You must train all new workers in your operating procedures developed under the previous prevention program element; if any of your more experienced workers need training on these procedures, you should also train them. Any time the procedures

are revised, you must train everyone using the new procedures. At least once every three years, you must provide refresher training on the operating procedures even if they have not changed. The training must cover all parts of the operating procedures, including information on the consequences of deviations and steps needed to address deviations.

You need not provide initial training for workers already operating a process as of June 21, 1999, if you in writing that the employees have the "required knowledge, skills, and abilities to safely carry out the duties and responsibilities as provided in the operating procedures" (§ 68.54(a)). This certification should kept in your files; you do not need to submit it to EPA.

You are not required to provide a specific amount of training or type of training. You should develop a training approach that works for you. For WWTPs, where the number of staff handling regulated substances is generally small, one-on-one training and on-the-job training may work best. You may have senior operators present the training or use trainers provided by vendors or other outside sources. The form and the length of the training will depend on your resources and your processes. If you can teach someone the basics in two hours and move them on to supervised work, that is all right. The important thing is that your workers understand how to operate safely and can carry out their tasks properly. We are interested in the results of the training, not the details of how you achieve them. Find a system that works for you. Exhibit 6-7 lists things that you may find useful in developing your training program.

You are also required to ensure that each worker trained has understood the training and is competent to operate the process safely. You may decide what kind or kinds of competency testing to use. Observation by a senior operator may be appropriate in many cases. If you provided classroom training, you may want to use both testing and demonstration or observation. You are required to report in the RMP on the type(s) of competency testing you use.

For WWTPs, training should cover the activities that could lead to releases of the toxic gases and flammables that are used in WWTPs. These activities should be identified in the hazard review and bear particular attention:

- Connecting, and disconnecting, cylinders of Chlorine and Sulfur Dioxide. Training should cover inspection of the fittings and tubing to assure that they are in good condition and inspection (and discard if necessary) of tools used for the job. Training should also include identification of vapor and liquid connections on the cylinders and identification of the operating conditions that will show that the connections are hooked up in reverse.

- Material handling of cylinders. Training should cover inspection of material handling equipment, including hoists, cylinder carriers and hooks, and cylinder chocks. Also, inspection for and removal of combustibles or flammables in storage areas should be a part of training.

EXHIBIT 6-7
TRAINING CHART

UWho needs training?	Clearly identify the employees who need to be trained and the subjects to be covered.
UWhat are the objectives?	Specify learning objectives, and write them in clear, measurable terms before training begins. Remember that training must address the process operating procedures.
UHow will you meet the training objectives?	Tailor the specific training modules or segments to the training objectives. Enhance learning by including hands-on training like using simulators whenever appropriate. Make the training environment as much like the working environment as you can, consistent with safety. Allow your employees to practice their skills and demonstrate what they know.
UIs your training program working?	Evaluate your training program periodically to see if your employees have the skills and know the routines required under your operating procedures. Make sure that language or presentation are not barriers to learning. Decide how you will measure your employees' competence.
UHow will your program work for new hires and refresher training?	Make sure all workers – including maintenance and contract employees – receive initial and refresher training. If you make changes to process chemicals, equipment, or technology, make sure that involved workers understand the changes and the effects on their jobs.

HOW DOES THIS TRAINING FIT WITH OTHER REQUIRED TRAINING?

You are required by OSHA to provide training under the Hazard Communication Standard (29 CFR 1910.1200); this training covers the hazards of the chemicals and steps to take to prevent exposures. DOT has required training for loading and unloading of hazardous materials (49 CFR part 172, subpart H). Some of that training will cover items in your operating procedures. You do not need to repeat that training to meet EPA's requirements. You may want to integrate the training programs, but you do not have to do so.

WHAT KIND OF DOCUMENTATION DO I NEED TO KEEP?

In the RMP, you are required to report on the date of the most recent review or revision of your training program. You are also required to report on the type of training required (e.g., classroom or on-the-job) and the type of competency testing used. You should keep on site any current training materials or schedules used. The rule does not require you to keep particular records of your training program. It is enough for you to have on site information that supports what is reported in the RMP and your implementation of the training program overall. You may want to keep an attendance log for any formal training courses and refresher training to ensure that everyone who needs to be trained is trained. Such logs will help you perform a

compliance audit or demonstrate compliance with the rule although you are not required to keep logs for this rule.

WHERE TO GO FOR MORE INFORMATION

The Water Environment Federation provides several training programs including the following:

- *Basic Course for Wastewater Treatment Plant Operators*, Instructor Set Order No. E0100GB, Student Workbook Order No. E0110GB.
- *Intermediate Course for Wastewater Treatment Plant Operators*, Instructor Set Order No. E0295GB, Student Workbook Order No. E0296GB.
- *Chlorination Skill Training Course*, Order No. E0312GB. Self Instruction Course.

In addition, the following may be useful:

- *Operation and Maintenance of Municipal Wastewater Treatment Plants* (MOP-11), Water Environment Federation.
- NFPA-820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
- *Guidelines for Process Safety Fundamentals for General Plant Operations*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1995.
- *Guidelines for Technical Planning for On-Site Emergencies*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1995.
- *Federally Mandated Training and Information* (Publication 12000), American Petroleum Institute.

6.6 MAINTENANCE (§ 68.56)

Preventive maintenance, inspection, and testing of equipment is critical to safe operations. Waiting for equipment to fail often means waiting for an accident that could harm people and the environment. Further, a thorough maintenance program will save you money by cutting down-time caused by equipment failures. Your hazard review and safety information will have identified equipment that is critical to safe operations. You should use that information you develop while putting together these documents and reviews to build your maintenance program. Exhibit 6-8 briefly summarizes the elements of a maintenance program that would satisfy EPA's rule.

EXHIBIT 6-8
MAINTENANCE GUIDELINES

Written procedures	Training	Inspection & testing
U You may use procedures provided by the vendor or trade association, etc., as the basis for your program. If you choose to develop your own, you must write them down.	**U** Train process maintenance employees in process hazards and how to avoid or correct an unsafe condition. **U** Make sure this training covers the procedures applicable to safe job performance.	**U** Inspect & test process equipment. **U** Use recognized and generally accepted good engineering practices. **U** Follow a schedule that matches the manufacturer's recommendations or that prior operating experience indicates is necessary.

WHAT DO I NEED TO DO?

You must prepare and implement procedures for maintaining the mechanical integrity of process equipment, and train your workers in the maintenance procedures. For most of the equipment in a WWTP, the manufacturer will have supplied maintenance instructions. These can be used to fulfill the requirements for maintenance procedures. Where such instructions are not available, you will need to develop them. In addition to the major pieces of equipment, you will need to develop inspection procedures that consider both repair or replacement requirements for the following items:

- **g** Fittings
- **g** Tubing
- **g** Pressure relief devices
- **g** Gauges, pressure switches, and other instrumentation.
- **g** Rotameters
- **g** Pressure regulators, and pressure gauges
- **g** Leak detectors
- **g** Eductors, vacuum mixers, or other devices used to mix chlorine, sulfur dioxide, and other regulated substances into waste water streams
- **g** Material handing equipment
- **g** Tools
- **g** All other equipment used to handle, transfer, or use the regulated substances.

Where there is the possibility of corrosion, these inspections are especially important. The regulated substances used are normally not corrosive, when they are dry. However, all of them can become highly corrosive if the equipment using them is wet. Attention to this aspect can be vital.

In larger plants, where there are storage tanks for chorine, sulfur dioxide or ammonia, the tanks and associated piping should be inspected regularly. Suppliers

are likely to be able to provide recommendations for this inspection and preventive maintenance.

You should develop a schedule for inspecting and testing your equipment based on manufacturers' recommendations or your own experience if that suggests more frequent inspection or testing is warranted.

HOW DO I START?

Your first step will probably be to determine whether you already meet all these requirements. If you review your existing written procedures and determine that they are appropriate, you do not need to revise or rewrite them. If your workers are already trained in the procedures and carry them out, you may not need to do anything else.

If you do not have written procedures, you will need to develop them. Your equipment vendors may be able to provide procedures and maintenance schedules. Using these as the basis of your program is acceptable unless your use varies from that contemplated by the vendor or manufacturer (see below). Your trade association may also be able to help you with industry-specific checklists. If there are existing industry standards, your trade association can provide you with the references. Copies of these may form the basis for your maintenance program. If there are federal or state regulations that require certain maintenance, you should use these as well.

You need to determine if procedures provided by vendors, manufacturers, trade associations, or others are appropriate for your operation. If your safety information indicates that you are operating in a standard way (e.g., using only parts designed for chlorine service in your chlorination system), you may assume that these other procedures will work for you. If you are using equipment for purposes other than those for which it was designed, you need to decide whether your use changes the kinds of maintenance required.

TRAINING

Once you have written procedures, you must ensure that your maintenance workers are trained in the procedures and in the hazards of the process. As with the training discussed in the previous section, how you provide this training is up to you. We believe that you are in the best position to decide how to train your workers. Vendors may provide the training or videos; you may already provide training on hazards and how to avoid or correct them as part of Hazard Communication Standard training under OSHA regulations. You do not need to repeat this training to comply with this rule.

If you hire contractors to do your maintenance, you should ensure that they are trained to carry out the procedures. Under the rule, any maintenance contractor is required to ensure that each contract maintenance worker is trained to perform the maintenance procedures developed by the facility. You can help this process by

providing training or by developing agreements with the contractor that give you the assurance that only trained workers will be sent to your site. For any outside worker, you must ensure that they are informed of the hazards of your particular process. If you have standard equipment and hire contractors that specialize in servicing your types of processes, you can ensure their knowledge through agreements with the contractor.

INSPECTION AND TESTING

You must establish a schedule for inspecting and testing equipment associated with covered processes. The frequency of inspections and tests must be consistent with manufacturer's recommendations, industry standards or codes, good engineering practices, and your prior operating experience. In particular, you should use your own experience as a basis for examining any schedules recommended by others. Many things may affect whether a schedule is appropriate. The manufacturer may assume a constant rate of use (e.g., the amount of substance pumped per hour). If your use varies considerably, the variations may affect the wear on the equipment. Extreme weather conditions may also impact wear on equipment.

Talk with your operators and maintenance personnel as you prepare or adopt these procedures and schedules. If their experience indicates that equipment fails more frequently than the manufacturer expects, you should adjust the inspection schedule to reflect that experience. Your hazard review will have identified these potential problem areas as well and should be used as you develop schedules. For example, if you determine that corrosion is one of the hazards of the process, your schedule must address inspections for corrosion and replacement before failure. Your trade association may also be able to provide advice on these issues.

WHAT KIND OF DOCUMENTATION MUST I KEEP?

In the RMP, you are required to report on the date of the most recent review or revision of your maintenance procedures and the date of the most recent equipment inspection or test and equipment inspected or tested. You must keep on site your written procedures and schedules as well as any agreements you have with contractors. The rule does not require that you keep particular records of your maintenance program. It is enough for you to have on site information that supports what is reported in the RMP and your implementation of the maintenance program overall. For example, you may want to keep maintenance logs to keep track of when inspections and tests were done.

WHERE TO GO FOR MORE INFORMATION

Codes and Standards: The following groups develop codes and standards that may help you determine the appropriate frequency and methods to use for testing and inspection: National Board Inspection Code, the American Society for Testing and Material, American Petroleum Institute, National Fire Protection Association, American National Standards Institute, American Society of Mechanical Engineers.

Guidance and Reports. The documents listed under Safety Information may be useful for maintenance procedures as well. In addition, the Chlorine Institute publishes pamphlets on chlorine system maintenance, including the following:

- *Maintenance Instructions for Chlorine Institute Standard Safety Valves, Type 1-1/2 JQ* (# 39).
- *Maintenance Instructions for Chlorine Institute Standard Angle Valve* (#40).
- *Maintenance Instructions for Chlorine Institute Standard Safety Valve, Type 4JQ* (#41).
- *Maintenance Instructions for Chlorine Institute Standard Excess Flow Valves* (#42).

Although the reports below target the chemical industry, you may find useful information in them:

- *Guidelines for Equipment Reliability Data with Data Tables*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1989.

- *Guidelines for Process Safety Documentation*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1995.

- *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* (API 510), American Petroleum Institute.

- *Tank Inspection, Repair, Alteration, and Reconstruction (Std 653)*, American Petroleum Institute.

Q & A
MAINTENANCE

Q. I have a chlorine tank. I lease the tank from the supplier. The supplier does all the maintenance. My staff never work on the equipment. How I do meet this requirement?

A. As part of your contract with the supplier, you should gain an agreement, in writing, that the supplier will provide maintenance and trained maintenance workers that meet the requirements of 40 CFR 68.56.

6.7 COMPLIANCE AUDITS (§ 68.58)

Any risk management program should be reviewed periodically to ensure that employees and contractors are implementing it properly. A compliance audit is a way for you to evaluate and measure the effectiveness of your risk management program. An audit reviews each of the prevention program elements to ensure that they are up-to-date and are being implemented and will help you identify problem areas and take corrective actions. As a result, you'll be running a safer operation.

WHAT DO I NEED TO DO?

At least every three years, you must certify that you have evaluated compliance with for the prevention program requirements for each covered process. At least one person on your audit team must be knowledgeable about the covered process. You must develop a report of your findings, determine and document an appropriate response to each finding, and document that you have corrected any deficiency.

You must review compliance with each of the required elements of the prevention program. Because Program 2 processes are generally simple, the audit should not take a long time. You may want to develop a simple checklist; Exhibit 6-9 provides a sample format.

Once you have the checklist, you, your chief operator, or some other person who is knowledgeable about your process, singly or as a team, should walk through the facility and check on relevant items, writing down comments and recommendations. For example, you may want to talk with employees to determine if they have been trained and are familiar with the procedures.

You must respond to each of the findings and document what actions, if any, you take to address problems. You should take steps to correct any deficiencies you find.

You may choose to have the audit conducted by a qualified outside party. For example, you may have someone from another part of your company do the audit or hire an expert in your process. If you do either of these, you should have an employee who works with or is responsible for the process accompany the auditor, both to understand the findings and answer questions.

Again, the purpose of the compliance audit is to ensure that you are continuing to implement the risk management program as required. Remember, the risk management program is an on-going process; it is not a set of documents that you develop and put on a shelf in case the government inspects your site. To be in compliance with (and gain the benefits of) the rule, procedures must be followed on a daily basis; documents must be kept up to date. The audit will check compliance with each prevention program element and indicate areas that need to be improved. You may choose to expand the scope to cover your compliance with other parts of the rule and the overall safety of your operation, but you are not required to do so.

EXHIBIT 6-9
SAMPLE AUDIT CHECKLIST
FOR SAFETY INFORMATION AND HAZARD REVIEW

Element	Yes/No/NA	Action/Completion Data
Safety Information		
MSDSs up-to-date?		
Maximum intended inventory determined?		
Determined Safe upper and lower temperature? Safe upper and lower pressures? Safe process flow rates? Compositions?		
Equipment specifications Tanks? Piping? Pressure relief valves? Emergency shutoff valves? Gauges? Pumps? Compressors? Hoses?		
Hazard Review		
Has equipment been inspected to determine if it is designed, manufactured, installed, and operated according to industry standards and codes?		
Are the results of the inspections documented?		
Have inspections been conducted after every major change?		

WHAT KIND OF DOCUMENTATION MUST I KEEP?

You must keep a written record of audit findings and your response to those findings and documents that deficiencies have been corrected. You must keep the two most recent audit reports, but you need not keep a report that is more than five years old. You may also want to keep a record of who conducted the audit, but you are not required to do this.

WHERE TO GO FOR MORE INFORMATION

- *Guidelines for Auditing Process Safety Management Systems*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1993.

Q & A
AUDITS

Q. Does the compliance audit requirement cover all of the Part 68 requirements or just the prevention program requirements?

A. The compliance audit requirement applies only to the prevention programs under Subpart C. If you have a Program 2 process, you must certify that you have evaluated compliance with the Program 2 prevention program provisions at least every three years to verify that the procedures and practices developed under the rule are adequate and are being followed. You may want to expand your audit to check other part 68 elements, but you are not required to do so.

6.8 INCIDENT INVESTIGATION (§ 68.60)

Incidents can provide valuable information about site hazards and the steps you need to take to prevent accidental releases. Often, the immediate cause of an incident is the result of a series of other problems that need to be addressed to prevent recurrences. For example, an operator's mistake may be the result of poor training. Equipment failure may result from improper maintenance or misuse. Without a thorough investigation, you may miss the opportunity to identify and solve these problems.

WHAT DO I NEED TO DO?

You must investigate each incident which resulted in, or could have resulted in, a catastrophic release of a regulated substance. A catastrophic release is one that presents an imminent and substantial endangerment to public health and the environment. Exhibit 6-10 briefly summarizes the steps you must take for investigating incidents. You should also consider investigating minor accidents or near misses because they may help you identify problems that could lead to more serious accidents; however, you are not required to do so under part 68.

EXHIBIT 6-10
INCIDENT INVESTIGATION REQUIREMENTS

UInitiate an investigation promptly.	Begin investigating no later than 48 hours following the incident.
USummarize the investigation in a report.	Among other things, the report must identify the factors contributing to the incident. Remember that identifying the root cause may be more important than identifying the initiating event. The report must also include any recommendations for corrective actions. Remember that the purpose of the report is to help management take corrective action.
UAddress the report's findings and recommendations.	Establish a system to address promptly and resolve the incident report findings and recommendations and document resolutions and corrective actions.
UReview the report with your staff and contractors.	You must share the report - its findings and recommendations - with affected workers whose job tasks are relevant to the incident.
URetain the report.	Keep incident investigation summaries for five years.

HOW DO I START?

You should start with a simple set of procedures that you will use to begin an investigation. You may want to assign someone to be responsible for compiling the initial incident data and putting together the investigation team. If you have a small facility, your "team" may be one person who works with the local responders, if they were involved.

The purpose of the investigation is to find out what went wrong and why, so you can prevent it from happening again. Do not stop at the obvious failure or "initiating event" (e.g., the hose was clogged, the operator forgot to check the connection); try to determine why the failure occurred. In many cases, the underlying cause will be what matters (e.g., the operator did not check the connection because the operating procedures and training did not include this step). If the accident occurred because of operator error, you should determine if the operator made the mistake because he or she had been trained inadequately or trained in the wrong procedures or because design flaws made mistakes likely. If you write off the accident as operator error alone, you miss the chance to take the steps needed to prevent such errors the next time. Similarly, if equipment fails, you should try to decide whether it had been used or maintained improperly.

Remember, your goals are to prevent accidents, not to blame someone, and correct any problems in your prevention program. In this way, you can prevent recurrences.

In some cases, an investigation will not take long. In other cases, if you have a complex facility, equipment has been severely damaged, or the workers seriously hurt, an investigation may take several days. You should talk with the operators who were in the area at the time and check records on maintenance (another reason for keeping logs). If equipment has failed in an unusual way, you may need to talk to the manufacturer and your trade association to determine if similar equipment has suffered similar failures.

You must develop a summary of the accident and its causes and make recommendations to prevent recurrences. You must address each recommendation and document the resolution and any actions taken. Finally, you must review the findings with operators affected by the findings.

WHAT KIND OF DOCUMENTATION MUST I KEEP?

You must maintain the summary of the accident investigation and recommendations and document resolutions and corrective actions. A sample format is shown in Exhibit 6-11 that combines all of these in a single form. Note that the form also includes accident data that you will need for the five-year accident history. These data are not necessarily part of the incident investigation report, but including them will create a record you can use later to create the accident history.

WHERE TO GO FOR MORE INFORMATION

Although the reports below target the chemical industry, you may find useful information in them:

- *Guidelines for Investigating Chemical Process Incidents*, Center for Chemical Process Safety of the American Institute of Chemical Engineers 1992.

- *Guide for Fire and Explosion Investigations* (NFPA 921), National Fire Protection Association.

6.9 CONCLUSION

Many of you will need to do little that's new to comply with the Program 2 prevention program, because complying with other Federal rules, state requirements, and industry-specific codes and standards results in compliance with many Program 2 elements. And if you've voluntarily implemented OSHA's PSM standard for your Program 2 process, you'll meet the lesser Program 2 prevention program requirements. No matter what choices you make in complying with the Program 2 prevention program, keep these things in mind:

EXHIBIT 6-11
SAMPLE INCIDENT INVESTIGATION FORMAT

Ammonia Tank Release		
Date: May 15, 1998; 3 pm	Substance: Ammonia	Quantity: 2 tons
Duration: 2 hours	Weather: 82 F, 8 mph winds	Date Investigation Started: May 16, 1998
Description:	Unloading hose split open and spilled substance; operator was in the main building and failed to notice spill for several minutes	
Findings	**Recommendations**	**Actions**
Hose split because the pressure rating was too low; design pressure requirement was overlooked	Replace hose with correctly rated pressure hose; compare all pressure ratings to actual, including deadhead pump pressure, and make any needed upgrades	Replaced hose as recommended; checked all pressure ratings
Operator failed to stay at the tank during loading	Conduct refresher training to stress necessity of remaining at the tank during loading	Refresher training provided; safety meetings added and held on a monthly basis to review safety issues
Tank required manual shutoff	Determine if automatic shutoff valve is feasible	Automatic shutoff valve installed

- Integrate the elements of your prevention program. For Program 2 owners and operators, a major change in any single element of your program should lead to a review of other elements to identify any effect caused by the change.

- Make accident prevention an institution at your site. Like the entire risk management program, a prevention program is more than a collection of written documents. It is a way to make safe operations and accident prevention the way you do business everyday.

- Check your operations on a continuing basis and ask if you can improve them to make them safer as well as more efficient.

APPENDIX 6A

HAZARD REVIEW CHECKLISTS, WHAT IF QUESTIONS,

AND HAZOP PROCEDURES

EXHIBIT 6A-1
GENERAL CONDITIONS, OPERATION AND MAINTENANCE
(FOR ANY WWTP)

General Conditions, Operation and Maintenance	Yes/No/NA	Comments
Are work areas clean?		
Are adequate warning signs posted?		
Is ambient temperature normally comfortable?		
Is lighting sufficient for all operations?		
Are the right tools provided and used?		
Is personal protective equipment (PPE) provided and adequate?		
Are containers and tanks protected from vehicular traffic?		
Are all flammable and combustible materials kept away from containers, tanks, and feed lines?		
Are containers, tanks, and feed line areas kept free of any objects that can fall on them (e.g., ladders, shelves?)		
Are leak detectors with local and remote audible and visible alarms present, operable, and tested?		
Are windsocks provided in a visible location?		
Are emergency repair kits available for each type of supply present?		
Are appropriate emergency supplies and equipment present, including PPE and self-contained breathing apparatus (SCBA)?		
Are emergency numbers posted in an appropriate spot?		
Are equipment, containers, and railcars inspected daily?		
Are written operating procedures available to the operators?		
Are preventative maintenance, inspections, and testing performed as recommended by the manufacturer and industry groups and documented?		

EXHIBIT 6A-2
HUMAN FACTORS
(GENERAL)

Human Factors	Yes/No/NA	Comments
Have operators been trained on the written operating procedures and the use of PPE in normal operations (or for operators on the job before June 21, 1999, have you certified that they have the required knowledge, skills, and ability to do their duties safely)?		
Do the operators follow the written operating procedures?		
Do the operators understand the applicable operating limits on temperature, pressure, flow, and level?		
Do the operators understand the consequences of deviations above or below applicable operating limits?		
Have operators been trained on the correct response to alarms and conditions that exceed the operating limits of the system?		
Are operators provided with enough information to diagnose alarms?		
Are controls accessible and easily understood?		
Are labels adequate on instruments and controls?		
Are all major components, valves, and piping clearly and unambiguously labeled?		
Are all components mentioned in the procedures adequately labeled?		
Are safe work practices, such as lockout/tagout, hot work, and line opening procedures followed?		
Are personnel trained in the emergency response plan and the use of emergency kits, PPE, and SCBAs?		
Are contractors used at the facility?		
Are contractors trained to work as safely as your own employees?		
Do you have programs to monitor that contractors are working safely?		

EXHIBIT 6A-3
CHECKLISTS FOR CHLORINE AND SULFUR DIOXIDE

	Yes/No/NA	Comments
Chlorine and Sulfur Dioxide - Siting		
Are storage, use, and transfer areas not located uphill from adjacent operations?		
Are storage, use, and transfer areas located away from sewer openings and other underground structures?		
Do storage, use, and transfer areas have easy access for emergency response?		
Are storage, use, and transfer areas free of combustible or incompatible materials and isolated from hydrocarbons in accordance with NFPA Standard No. 49, Hazardous Chemicals Data?		
Are storage, use and transfer areas downwind of or separated from most operations and support areas and ventilation intakes based on prevailing wind direction?		
Are storage, use, and transfer areas isolated from sources of corrosion, fire, and explosion and protected from vehicle impact?		
Are storage, use, and transfer areas located away from residences and facility boundaries?		
If cylinders are stored outside, are they protected from impact by vehicular traffic?		
Chlorine and Sulfur Dioxide - Hazard Recognition		
Are material safety data sheets (MSDSs) readily available to those operating and maintaining the system?		
Do employees understand that there are certain materials with which Cl_2 (SO_2) must not be mixed?		
Do employees understand the toxicity, mobility, and ability of Cl_2 (SO_2) to sustain combustion?		
Do employees understand the consequences of confining liquid Cl_2 (SO_2) without a thermal expansion device?		
Do employees understand the effect of moisture on the corrosive potential of Cl_2 (SO_2)?		

	Yes/No/NA	Comments
Do employees understand the effects of fire and elevated temperature on the pressure of confined chlorine (SO_2) and the potential for release?		
Chlorine and Sulfur Dioxide - Container Shipment Unloading		
Is the truck inspected for wheel chocks, proper position, and condition of crane?		
Are adequate warning signs posted? Are there “stops”?		
Is the shipment inspected for leakage, general condition, currency of hydrostatic test, and valve protective housing before accepting?		
Are containers placed in the 6 o’clock/12 o’clock position for storage to reduce the chance of a liquid leak through the valve?		
Chlorine and Sulfur Dioxide - Bulk Shipment Unloading		
Do procedures call for hand brakes to be set and wheels chocked before unloading?		
Do procedures call for safety systems to be inspected prior to making connections for unloading or between storage tanks and transfer or distribution systems?		
For railcars, are derails to protect the open end located at least 50 feet from the car being protected?		
Are railcars staged at dead-end tracks and guarded against damage from other railcars and motor vehicles?		
Are caution signs placed at each derail and as appropriate in the vicinity of Cl_2 (SO_2) storage, use, and transfer areas?		
Does the transfer operation incorporate an emergency shutoff system?		
Is a suitable operating platform provided at the transfer station for easy access and rapid escape?		
Is padding air for railcars from a dedicated, flow-limited, dry (to -40 EF or below), and oil-free source?		
Is tank car attended as long as the car is connected, in accordance with DOT regulations?		
Building and Housing Cl_2 (SO_2) Systems	**Yes/No/NA**	**Comments**
Does the building conform with local building and fire codes and NFPA-820?		

	Yes/No/NA	Comments
Is the building constructed of non-combustible materials?		
If flammable materials are stored or used in the same building, are they separated from the Cl_2 (SO_2) areas by a fire wall?		
Is continuous leak detection, using area Cl_2 (SO_2) monitors, provided in storage and process areas?		
Are two or more exits provided from each Cl_2 (SO_2) storage and process area and building?		
Is the ventilation system appropriately designed for indoor operations (and scrubbing, if required) by local codes in effect at the time of construction or major modification?		
Are the exhaust ducts near floor level and the intake elevated?		
Can the exhaust fan be remotely started and stopped?		
If Cl_2 and SO2 are stored in the same building, are storage rooms separated as required?		
Chlorine and Sulfur Dioxide - Piping and Appurtenances		
Do piping specifications meet Cl_2 (SO_2) requirements for the service?		
Do you require suppliers to provide documentation that all piping and appurtenances are certified “for chlorine service” or “for sulfur dioxide service” by the manufacturer?		
Are piping systems properly supported, adequately sloped to allow drainage, and with a minimum of low spots?		
Is all piping protected from all risks of excessive fire or heat?		
Is an appropriate liquid expansion device or vapor pressure relief provided on every line segment or device that can be isolated?		
Chlorine and Sulfur Dioxide - Design Stage Review of New/Modified Process		
Is the system designed to operate at lowest practical temperatures and pressures?		
If Cl_2 (SO_2) demand is low enough, is the system designed to feed gaseous chlorine (SO_2) from the storage container, rather than liquid?		
Have the lengths of liquid Cl_2 (SO_2) lines been minimized (reduces quantity of chlorine in lines available for release)?		

	Yes/No/NA	Comments
Are low-pressure alarms and automatic shutoff valves provided on Cl_2 (SO_2) feed lines?		
Are vent-controlled spill collection sumps provided and floors sloped toward sumps for stationary tanks and railcars?		
Are vaporizers provided with automatic gas line shutoff valve, downstream pressure reducing valve, gas flow control valve, temperature control system and interlocks to shut down gas flow on low vaporizer temperature, and appropriate alarms in a continuously manned control room?		
Do vaporizers have a limited heat input capacity?		
Are curbs, sumps, and diking that minimize the surface of potential spills provided for stationary tanks and railcars?		

EXHIBIT 6A-4
CHECKLIST FOR ANHYDROUS AMMONIA SYSTEMS

	Yes/No/NA	Comments
Anhydrous Ammonia - Basic Rules		
Does the storage tank have a permanently attached nameplate?		
Are container(s) at least 50 feet from wells or other sources of potable water supply?		
Are container(s) painted white or other light reflecting colors and maintained in good condition?		
Is the area free of readily ignitable materials?		
Are all main operating valves on tanks identified to show liquid or vapor service?		
Anhydrous Ammonia - Appurtenances		
Are all appurtenances designed for maximum working pressure and suitable for ammonia service?		
Do all connections to containers have shut-off valves as close to container as practicable (except safety relief devices and gauging devices)?		
Are the excess flow and/or back pressure check valves located inside of the container or at a point outside as close as practicable to where line enters container?		
Are excess flow valves plainly and permanently marked with name of manufacturer, catalog number, and rated capacity?		
Anhydrous Ammonia - Piping		
Are piping and tubing suitable for ammonia service?		
Are provisions made for expansion, contraction, jarring, vibration and settling?		
Is all exposed piping protected from physical damage from vehicles and other undue strain (2,000 lb. pull)?		
Anhydrous Ammonia - Hoses		
Does the hose conform to TFI-RMA specifications for anhydrous ammonia?		

	Yes/No/NA	Comments
Is it 350 psig working, 1750 psig - burst?		
Is it marked every 5 feet with "Anhydrous Ammonia, xxx psig (maximum working pressure), manufacturer's name or trademark, year of manufacture?		
Anhydrous Ammonia - Safety Relief Devices		
Are safety relief valves installed?		
Are they vented upward and unobstructed to the atmosphere?		
Do they have a Rain/Dust Cap?		
Are shut-off valves not installed between safety relief valve and container?		
Are safety relief valves marked with "NH3" or "AA", psig valve is set to start-to-discharge, CFM flow at full open, manufacturer's name, and catalog number?		
Is flow capacity restricted on upstream or downstream side?		
Are hydrostatic relief valve installed between each pair of valves in liquid piping or hose?		
Anhydrous Ammonia - Safety		
Are there two suitable full face masks with ammonia canisters as approved by the Bureau of Mines? Are self-contained breathing air apparatus required in concentrated atmospheres?		
Is an easily accessible shower or a 50 gallon drum of water available?		
Anhydrous Ammonia - Transfer of Liquid		
Are pump(s) designed for ammonia service and at least 250 psig working pressure?		
Does P.D. pump have relief valve installed?		
Is a 0-400 psi pressure gauge installed on pump discharge?		
Are loading/unloading lines fitted with back flow check or excess flow valves?		
Are caution sign(s) posted when rail car(s) are loading/unloading?		
Are containers equipped with an approved liquid level gauging device (except those filed by weight)?		

	Yes/No/NA	Comments
Are containers fitted with a fixed tube liquid level gauge at 85% of water capacity?		
Anhydrous Ammonia - Stationary Tank		
Are non-refrigerated container(s) designed for a minimum 250 (265 psig in CA) psig pressure?		
Are all liquid and vapor connections to container(s) except safety relief valves, liquid gauging and pressure gauge connections fitted with orifices not larger than No. 54 drill size equipped with excess-flow valves?		
Are storage containers fitted with a 0-400 psi ammonia gauge?		
Are they equipped with vapor return valves(s)?		
Are containers marked on at least two sides with “Anhydrous Ammonia” or “Caution - Ammonia” in contrasting colors and minimum 4 inch high letters?		
Is a sign displayed stating name, address and phone number of nearest representative, agent or owner?		
Are containers installed on substantial concrete, masonry or structural steel supports?		
Are ammonia systems protected from possible damage by moving vehicles?		

EXHIBIT 6A-5
CHECKLIST FOR AQUEOUS AMMONIA SYSTEMS

	Aqueous Ammonia	Yes/No/NA	Comments
1.	Are storage tank(s) painted white or other light reflecting colors and maintained in good order?		
2.	Is storage area free of readily ignitable materials?		
3.	Are storage tank(s) kept away from wells or other sources of potable water supply?		
4.	Are storage tank(s) located with ample working space all around?		
5.	Are storage tank(s) properly vented and away from areas where operators are likely to be?		
6.	Does receiving system include a vapor return?		
7.	Is storage capacity adequate to receive full volume of delivery vehicle?		
8.	Are storage tank(s) secured against overturn by wind, earthquake and/or floatation?		
9.	Are tank bottom(s) protected from external corrosion?		
10.	Is aqua ammonia system protected from possible damage from moving vehicles?		
11.	Are storage tank(s) labeled as to content?		
12.	Are all appurtenances suitable for aqua ammonia service?		
13.	Are all storage tank(s) fitted with liquid level gauges?		
14.	Are liquid level gauge(s) adequately protected from physical damage?		
15.	If tubing is used, is it fitted with a fail closed valve?		
16.	Are all storage tank(s) fitted with overfill fittings or high level alarms?		
17.	Are tank(s) fitted with pressure/vacuum valves?		
18.	Is an ammonia gas scrubber system used?		
19.	Are piping and hose materials suitable for aqua ammonia service?		

	Aqueous Ammonia	Yes/No/NA	Comments
20.	Is piping free of strain and provision made for expansion, contraction, jarring, vibration and settling?		
21.	Is all exposed piping protected from physical damage from moving vehicles and other undue strain?		
22.	Are hoses securely clamped to hose barbs?		
23.	Are hoses inspected and renewed periodically to avoid breakage?		
24.	Are pump(s) designed for aqua ammonia service?		
25.	Are pump(s) fitted with splash guard around seals?		
26.	Are pump(s) fitted with coupling guard(s)?		
27.	Do pump(s) have local start/stop stations?		
28.	Are two (2) suitable full face masks with ammonia canisters as approved by the Bureau of Mines available? Self-contained breathing air apparatus required in concentrated atmospheres.		
29.	Is an easily accessible quick acting shower with bubble fountain or 250-gallon drum of clean water available?		
30.	Is an extra pair of chemical splash proof goggles and/or full face shields available?		
31.	Is an extra set of ammonia resistant gloves, boots, coat and apron available?		
32.	Are fire extinguishers and a first aid kit available?		
33.	Are handlers/operators wearing their goggles and gloves when working with aqua ammonia?		
34.	Are safety and first aid information posted?		
35.	Are emergency phone numbers and individuals to contact posted?		

EXHIBIT 6A-6
SAMPLE WHAT-IF ANALYSIS PROCEDURE AND QUESTIONS

Analysis Procedure. The steps in a What-If/Checklist analysis are as follows:

1. Select the team (personnel experienced in the process)
2. Assemble information (piping and instrumentation drawings (P&IDs), process flow diagrams (PFDs), operating procedures, equipment drawings, etc.)
3. Develop a list of What-If questions (use the ones in Exhibit 6A-6 if you want)
4. Assemble your team in a room where each team member can view the information
5. Ask each What-If question in turn and determine:
   - What can cause the deviation from design intent that is expressed by the question?
   - What adverse consequences might follow ?
   - What are the existing design and procedural safeguards?
   - Are these safeguards adequate?
   - If these safeguards are not adequate, what additional safeguards does the team recommend?
6. As the discussion proceeds, record the answers to these questions in tabular format. Exhibit 6A-8 provides an example.
7. Do not restrict yourself to the list of questions that you developed before the project started. The team is free to ask additional questions at any time.
8. When you have finished the What-If questions, proceed to examine the checklist. The purpose of this checklist is to ensure that the team has not forgotten anything. While you are reviewing the checklist, other What-If questions may occur to you.
9. Make sure that you follow up all recommendations and action items that arise from the hazards evaluation.

A. What -If Questions for Chlorine and Sulfur Dioxide Systems

Movement of 1-Ton Cl_2 (SO_2) Cylinders

What if the cylinder is dropped from the lifting apparatus?

What if the truck rolls forward or backward?

What if a cylinder rolls and drops from the truck?

What if the cylinder swings while being lifted?

What if the Cl_2 (SO_2) container is not empty when removed from service?

What if the automatic container switchover system fails?

What if a Cl_2 (SO_2) cylinder is delivered instead of SO_2 (Cl_2)

What if the cylinder is not in good condition?

Ton Cylinders on Trunnion, including pigtails, (subheader lines) to Main Header Lines

What if pigtails rupture while connected on-line?

What if pigtail connections open or leak when pressure is applied?

What if something is dropped onto cylinder or connection?

What if cracks develop in the ton cylinder flexible connection?

What if liquid Cl_2 (SO_2) is withdrawn through the vapor lines from the ton cylinder?

What if the cylinder valve cannot be closed during an emergency?

What if there are pinholes or small leaks at the fusible plugs?

What if ton cylinder ends change shape from concave to convex?

What if liquid is trapped between two closed valves and the temperature rises?

What if there is a fire near the cylinders?

What if the operator leaves the valve open and disconnects the pigtail?

What if water enters the system?

Cl_2 (SO_2) Headers in the Chlorination (Sulfonation) Room

What if the pressure relief valve sticks open?

What if a valve leaks?

What if there is inadequate flow in the gas line (e.g., filter clogged)?

Evaporators

What if there is overpressure in the evaporator?

What if there is high temperature in the evaporator?

What if there is low temperature in the evaporator?

What if rupture disks leak?

What if the vacuum regulator valve fails?

What if there is a gas pressure gauge leak?

What if the vacuum regulator check unit fails?

What if there is liquid Cl_2 (SO_2) carryover to the vacuum regulating valve downstream of the evaporator?

Chlorination (Sulfonation) and Pipes to Injectors

What if there are leaks in the chlorinator (sulfinator) unit?

What if there is rupture of the pipe from the chlorinator to the injector?

What if there is backflow of water into the Cl_2 (SO_2) line?

What if the water pump is not working?

General

What if there is a power failure?

What if Cl_2 (SO_2) is released during maintenance?

What if a Cl_2 (SO_2) leak is not detected?

What if there is moisture in the Cl_2 (SO_2) system?

Scrubbers

What if the system loses scrubber draft?

What if the system loses scrubber solution?

What if the manual vent to the scrubber is opened during operation?

What if the leak tightness of the building is compromised during emergency operation of the scrubbers?

Tank Trucks

What if the liquid hose leaks or ruptures?

What if the vapor return hose leaks or ruptures?

What if the truck moves?

What if the mass of Cl_2 (SO_2) in the truck exceeds the capacity of the tank?

What if the Cl_2 tank truck is connected to an SO_2 vessel (or vice versa)?

What if there is something other than Cl_2 (or SO_2) in the truck?

What if there is a fire under or near the truck?

What if the truck collides with pipework or a building housing Cl_2 (SO_2) storage vessels?

Railcars

What if the liquid hose leaks or ruptures?

What if the padding air is moist?

What if the padding air hose ruptures?

What if the railcar moves?

What if the relief valve lifts below the set pressure?

What if there is a fire under or near the truck?

What if there is a fire on or near the railcar?

B. What-If Questions for Ammonia Systems

Storage Vessel

What if the vessel is overfilled?

What if there is fire under or near the vessel?

What if the relief valve fails to lift on demand?

What if the relief valve opens below its set pressure?

What if the deluge system fails to work on demand?

Tank Truck Unloading

What if the liquid unloading hose partially ruptures?

What if the liquid unloading hose completely ruptures?

What if the tank truck moves?

What if the tank truck drives away before the hose is disconnected?

What if the vapor return hose partially or completely ruptures?

What if valves are not completely closed before disconnecting the hoses?

What if the tank truck contains something other than ammonia?

What if the ammonia in the tank truck contains excess oxygen?

C. What-If Questions for Digester Systems

What if something falls onto a digester cover?

What if relief valves on a digester open?

What if an intermediate digester gas storage vessel fails?

What if air is introduced into the gas collection system?

What if the flare fails to operate?

What if the gas collection header leaks or ruptures or becomes blocked?

What if a digester gas compressor fails catastrophically?

What if there is a digester gas leak into a building (digester building, compressor room, boiler room)?

What if the digester gas pressure exceeds the cover pressure rating?

What if the floating digester gas cover jams or tilts?

D. General Questions

What if the ambient temperature is abnormally high?

What if the ambient temperature is abnormally low?

What if there is a hurricane?

What if there is a tornado?

What if there is flooding?

What if there is a heavy snowfall?

What if there is an earthquake?

What if there is a tidal wave?

What if there is a failure of electric power?

Exhibit 6A-7
EXAMPLE WHAT-IF/CHECKLIST LOG SHEET

Company: Sheet Name:
Facility: Reference:
PHA Date: Unit:
Leader/Secretary: Drawing Number:
Process: Print Date/Time:
Team Members: Description:

Item	Equipment/Activity	Questions	Causes	Consequence/Hazards	Safeguards	Safeguards adequate?	Recommendations
4.1	Generic Pressure Vessel	What if the set pressure of the equipment SRV is more than the design pressure of the equipment?	Incorrectly set valve purchased or returned after maintenance at contractor's shop	Potential for rupture and release of contents of vessel	Manufacturer or repair shop's QA	Y	None
4.2	Generic Pressure Vessel	What if the SRV is incorrectly sized?	Design basis for SRV incorrectly chosen or SRV sized for vapor flow when two-phase or liquid flow is possible	SRV cannot relieve pressure, potential rupture	Valves purchased for specific service	Y	None
4.3	Generic Pressure Vessel	What if the SRV opens below its set-pressure?	Vibration, incorrect design, weakened SRV spring, failure due to inadequate PM program	Release of vapor at relatively low pressure	PM program	N	Develop PM program for SRVs
4.4	Generic Pressure Vessel	What if there is a fire near or under the vessel?	Spillage of flammable liquid from nearby vessel	High pressure in vessel, potential rupture.	SRVs: Deluge system: Separation distances: Keep flammables away from vessel	Y	None

EXHIBIT 6A-8
HAZOP ANALYSIS GUIDE WORDS AND MEANINGS

In the approach, each guide word is combined with relevant process parameters and applied at each point (study node, process section, or operating step) in the process that is being examined.

Guide Words	Meaning
No	Negation of the Design Intent
Less	Quantitative Decrease
More	Quantitative Increase
Part Of	Other Material Present by Intent
As Well As	Other Materials Present unintentionally
Reverse	Logical Opposite of the Intent
Other Than	Complete Substitution

COMMON HAZOP ANALYSIS PROCESS PARAMETERS

Flow	Time	Frequency	Mixing
Pressure	Composition	Viscosity	Addition
Temperature	pH	Voltage	Separation
Level	Speed	Information	Reaction

The following is an example of creating deviations using guide words and process parameters:

Guide Words		Parameter		Deviation
NO	+	FLOW	=	NO FLOW
MORE	+	PRESSURE	=	HIGH PRESSURE
AS WELL AS	+	ONE PHASE	=	TWO PHASE
OTHER THAN	+	OPERATION	=	MAINTENANCE

MORE + LEVEL = HIGH LEVEL

Guide words are applied to both the more general parameters (e.g., react, mix) and the more specific parameters (e.g., pressure, temperature). With the general parameters, it is not unusual to have more than one deviation from the application of one guide word. For example, “more reaction” could mean either that a reaction takes place at a faster rate, or that a greater quantity of product results. On the other hand, some combinations of guide words and parameters will yield no sensible deviation (e.g., “as well as” with “pressure”).

How to Perform a Hazard and Operability (HAZOP) Review

1. Select the team.
2. Assemble information (P&IDs, PFDs, operating procedures, equipment drawings, etc.).
3. Assemble your team in a room where each team member can view P&IDs.
4. Divide the system you are reviewing into nodes (you can preset the nodes, or the team can choose them as you go along).
5. Apply appropriate deviations to each node. For each deviation, address the following questions:

   - What can cause the deviation from design intent?
   - What adverse consequences might follow ?
   - What are the existing design and procedural safeguards?
   - Are these safeguards adequate?
   - If these safeguards are not adequate, what does the team recommend?

6. As the discussion proceeds, record the answers to these questions in tabular format as shown below.

EXAMPLES OF LINE-BY-LINE TABLES USE IN A HAZOP

Node No:	**1**
From:	**Tanker Truck**
To:	**Ammonia Storage Vessel**
Drawing No:	
Line ID:	
Date:	
Node Description:	**Liquid loading line from tanker truck to ammonia vessel.**

Keyword	Deviation	Causes	Consequences	Safeguard	Adequate?	Recom-mendation
Flow	High	None identified	None	N/A		N
Flow	Low	Malfunction of truck equipment, blockage in line, excess pressure in tank or check valve failure	Operational problems	N/A		N
Flow	No	Malfunction on truck, or vapor line excess flow valve snaps shut	Operational problems	N/A		N
		Hose Rupture	Ammonia Leak	Emergency shutdown features	N	Y[1]
Flow	Reverse	Check valve and excess flow valve failure with hose rupture	Vapor release from vessel	Check valve, excess flow value and hose inspections	Y	N
		Block valves not closed when hose disconnected	Vapor release from vessel	Operator training	Y	N

[1]Arbitrary example of recommendation: Currently, the truck must park so far away from the tank that it is necessary to connect two lengths of hose. Investigate the ways in which truck unloading can be accomplished using only one length of hose.

Node No:	**1**
From:	**Tanker Truck**
To:	**Ammonia Storage Vessel**
Drawing No:	
Line ID:	
Date:	
Node Description:	**Liquid loading line from tanker truck to ammonia vessel.**

Keyword	Deviation	Causes	Consequences	Safeguard	Adequate?	Recom-mendation
Flow	Wrong Type	Delivery of wrong material	Unknown	Operational safeguards	Y	N
Flow	In addition	Water, oxygen, oil	Contamination, corrosion	Manufacturer's quality control	Y	N
Pressure	High	Valve closed, blockage, overfill vessel	Ammonia overflow or rupture	Relief valves, level gauges	Y	N

EXAMPLES OF LINE-BY-LINE TABLES (CONTINUED)

Node No:	**2**
From:	**Ammonia Storage Vessel**
To:	
Drawing No:	
Line ID:	
Date:	
Node Description:	**Ammonia storage vessel's design pressure is 265 psig at 250 degrees F. Working capacity is 15,000 gallons. Maximum level allowed in the tank is 85%, but normal operating procedure is 75%.**

Keyword	Deviation	Causes	Consequences	Safeguard	Adequate?	Recom-mendation
Pressure	High	Fire	Relief valve opens	Deluge system	Y	N
Pressure	Low	Vaporizer malfunction	None	N/A	N/A	N
Temp	High	See High Pressure			N/A	N
Temp	Low	See Low Pressure			N/A	N
Level	High	Overfilling	Relieve valve opens	Procedural	Y	N
Level	Low	Failure to order	None	N/A	N/A	N